

Comment on “On the problem of initial conditions in cosmological N-body simulations” (EpL 57, 322)

A. DOMÍNGUEZ¹ and A. KNEBE²

¹ *Max-Planck-Institute für Metallforschung, Heisenbergstr. 3, D-70569 Stuttgart, FRG*

² *Centre for Astrophysics & Supercomputing, Swinburne University, Mail #31, P.O. Box 218, Hawthorn, Victoria, 3122, Australia*

In the Letter [1], the initial conditions (IC's) of cosmological N-body simulations by the *Virgo Consortium* [2] are analyzed and it is concluded that the density fluctuations are rather different from the desired ones. We have repeated the analysis of the IC's using our own code and the code provided by the authors of [1], obtaining results that disprove the criticisms.

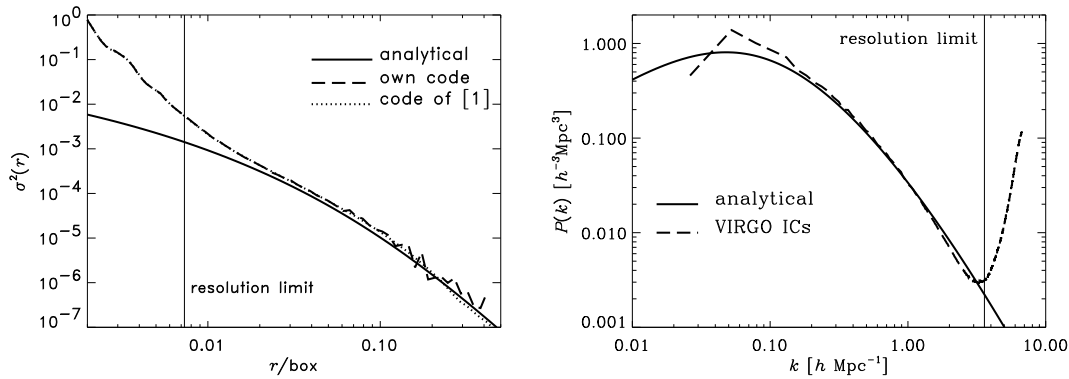


Fig. 1 – *Left*: density variance in balls of radius r (in units of the box size), estimated with our code and the one provided by the authors of [1]. *Right*: estimated power spectrum. The resolution limit corresponds to a distance $\approx 2\langle\Lambda\rangle$.

Fig. 1 shows the density variance, $\sigma^2(r)$, computed for the initial conditions of the SCDM1 model of the *Virgo Consortium* [2]. For $\sigma^2(r)$ we used the estimator quoted in [1]: variance of density fluctuations in 20000 spheres centered at random positions. The theoretical CDM behaviors have been computed with the power spectrum employed by the *Virgo Consortium* [2], and they correct the wrong ones in [1]. For completeness, we also show the estimated power spectrum, $P(k)$. We find that the estimated value of $\sigma^2(r)$ *does follow* the theoretical CDM prediction in an intermediate range of scales $2\langle\Lambda\rangle \lesssim r \lesssim L/2$ ($\langle\Lambda\rangle$ being the mean interparticle separation and L the box size). On scales outside this trustworthy range, the expected systematic departures due to discreteness and finite-size set in. In the same way,

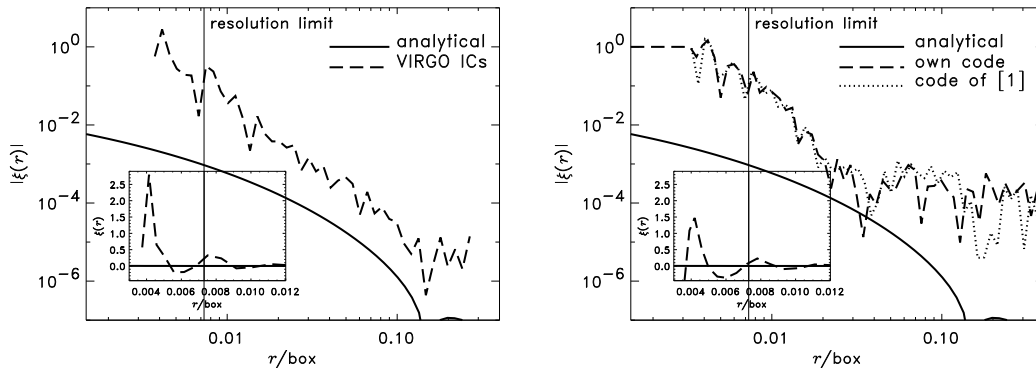


Fig. 2 – Absolute value of the estimated correlation function; the inset panel shows the oscillatory behaviour of $\xi(r)$ for small separations. *Left*: random balls are allowed to overlap. *Right*: they are constrained to avoid overlap.

the estimate of $P(k)$ also agrees with the desired CDM behavior in the intermediate range $2\pi/L \lesssim k \lesssim \pi/\langle\Lambda\rangle$.

Fig. 2 shows the estimated $\xi(r)$. We used the estimator quoted in [1], in turn a simple modification of the one for σ^2 (variance in spherical *shells* centered at randomly chosen *particles*). The estimate of $\xi(r)$ exhibits noticeable fluctuations around zero, whose amplitude is larger than the desired CDM decay. This amplitude is comparable to the variation of the estimate when using different random seeds for the random sphere centers. Such a noise also arises when estimating $\xi(r)$ for simple test cases whose correlation is known theoretically (uncorrelated particles, particles at the nodes of a lattice). This suggests that these fluctuations are mainly noise of the ξ -estimator employed in [1]. In these circumstances, a systematic departure from the CDM behavior provoked by the method how the IC's are generated cannot be assessed.

We also learnt that the results shown in [1] were derived in reality with a modification of the quoted estimators: the probing spheres were constrained to avoid mutual overlap, so that their number is effectively smaller than the intended 20000 for r large enough. We have observed that this leads to no detectable significant difference when estimating σ , but the estimated $\xi(r)$ tends to be larger in the large- r end compared to the unconstrained estimate. This sensitivity on the number of probing spheres throws further doubts on the reliability of the measured $\xi(r)$, and it suggests looking for better estimators.

Our conclusions are: (i) $\sigma^2(r)$ and $P(k)$ reproduce very well the desired CDM behavior in the expected intermediate range of scales; (ii) the estimator of $\xi(r)$ employed in [1] is too noisy to allow one to claim that $\xi(r)$ does or does not follow the expected behavior; (iii) hence, these measurements provide no evidence against the procedure employed to generate the IC's.

REFERENCES

- [1] BAERTSCHIGER T., SYLOS-LABINI F., *Europhys. Lett.*, **57** (2002) 322.
- [2] JENKINS A. ET AL., *Astrophys. J.*, **499** (1998) 20.